CMIP6 Climate Model Improvements in Clouds and Water Vapor Simulations: Preliminary Results

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Aura Science Team Meeting 2019

CMIP6 Scientific Focus

1. **Clouds, Circulation and Climate Sensitivity**
   - ➢ **Cloud Feedbacks**
   - ➢ **Emergent Constrains on ECS**

2. **Changes in Cryosphere**

3. **Climate Extremes**
   - ➢ **Impacts of Global Warming >1.5℃?**

4. **Regional Climate Information**

5. **Regional Sea-level Rise**

6. **Water Availability**

WCRP Grand Challenges

CMIP6 Experiment Focus

1. How does the Earth System respond to forcing?

2. What are the origins and consequences of systematic model biases?

3. How can we assess future climate changes given climate variability, predictability and uncertainties?

JPL

CMIP6 staticstics : More institutions, more models, more experiments, more data

Check status at PCMDI website: https://pcmdi.llnl.gov/CMIP6/

- **44 institutions registered for CMIP6**

- **100 models are registered**

- **287 experiments defined**

- **> 20 PB of model output expected**

Aura Science Objectives

1. **To evaluate CMIP6 clouds and water vapor simulations using observational metrics based on the Aura and A-Train data to assess the model improvements from CMIP5 to CMIP6.**

    1. **Bi-Variate Metrics (BVM)**
    2. **Taylor Diagram**
    3. **Quantitative grading systems**
    4. **Conditional sampling diagrams**
    5. **Metrics for diurnal, seasonal and interannual variabilities**

2. To identify key physical mechanisms responsible for inter-model differences in climate-sensitive metrics.

3. To apply a suite of emergent constraints of climate-sensitive metrics onto CMIP6 models to infer the realism of future climate changes in temperature and precipitation.
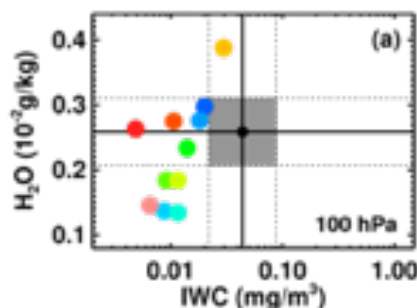
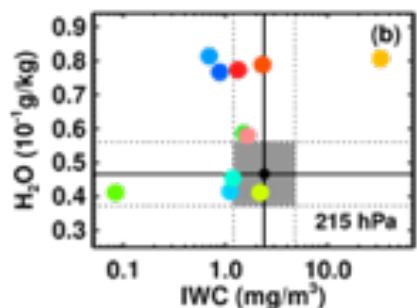# Some Preliminary Results for CMIP6
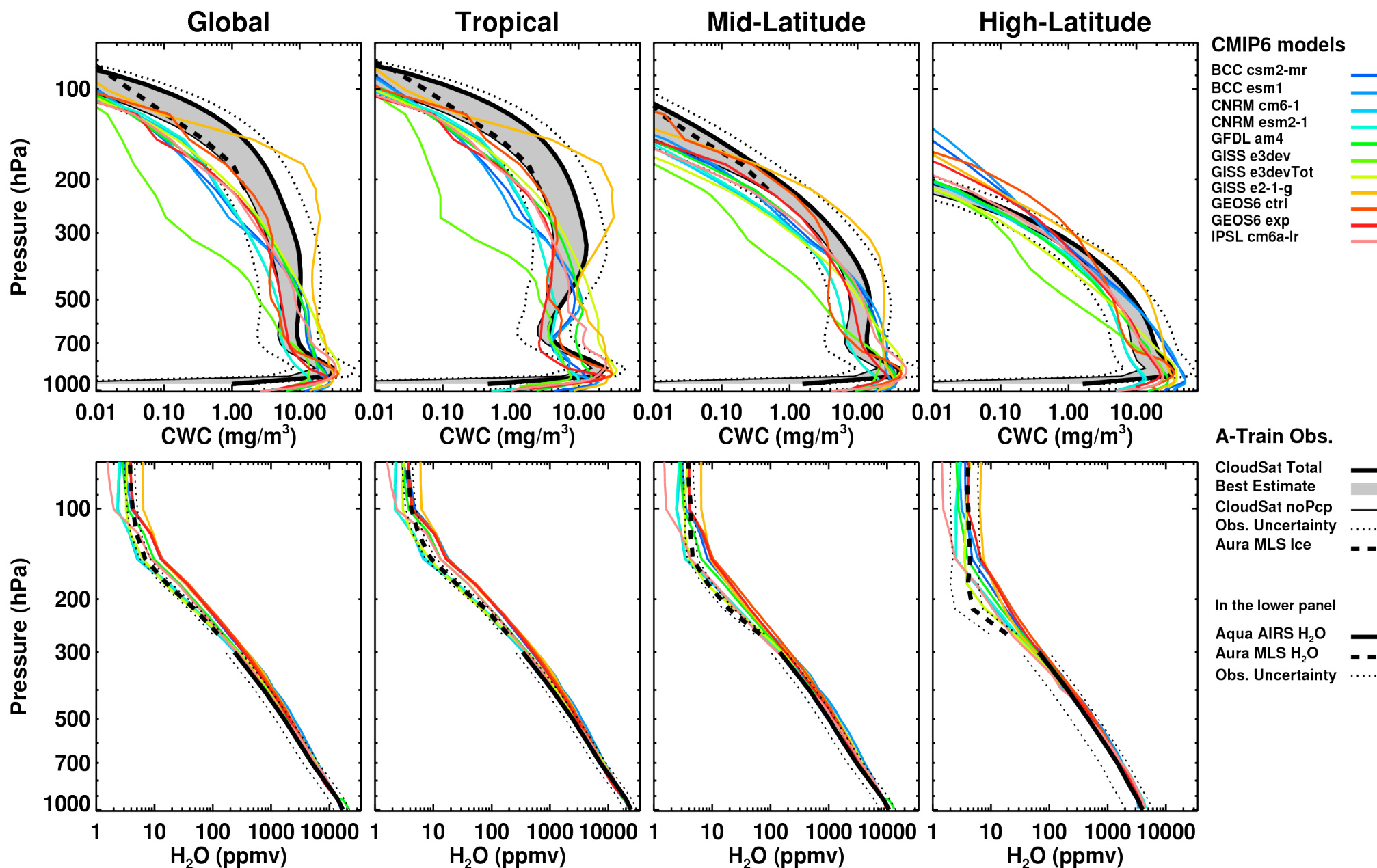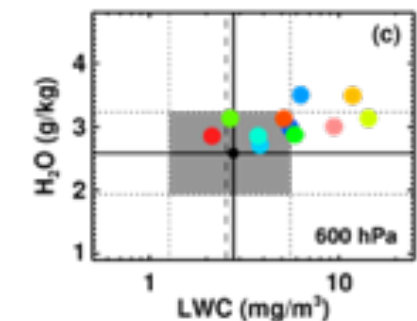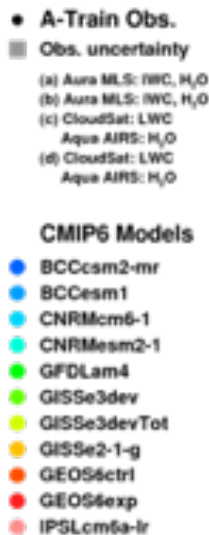
Some Preliminary Results for CMIP6

Spatial Mean

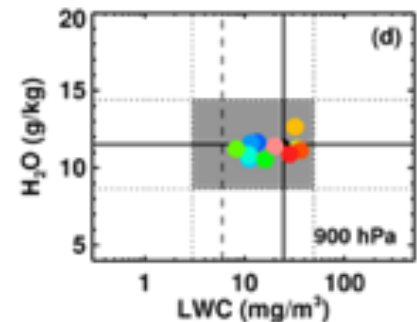**Spatial variance and correlations**

100 hPa

215 hPa

600 hPa

900 hPa
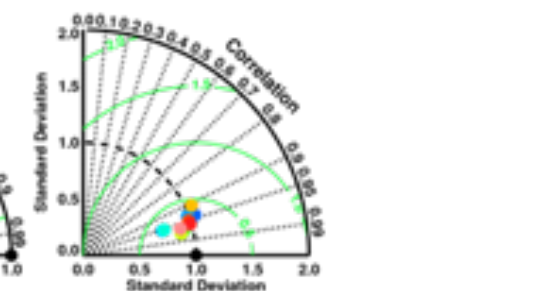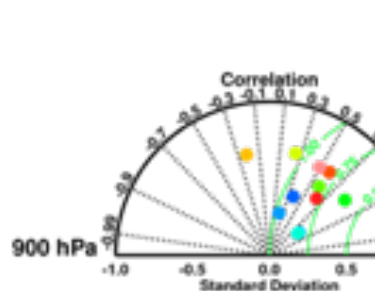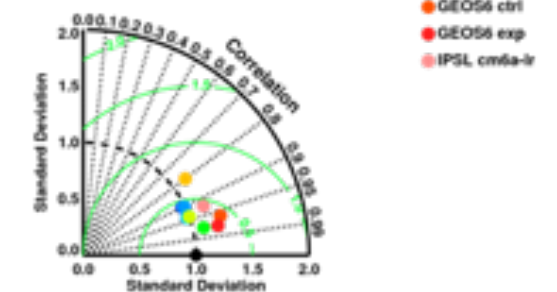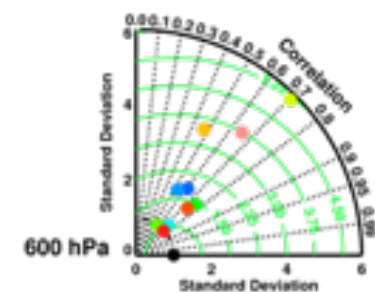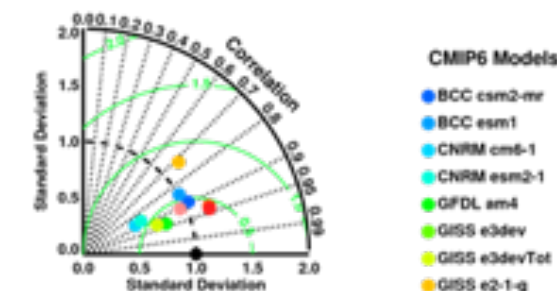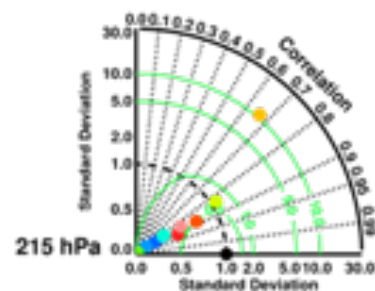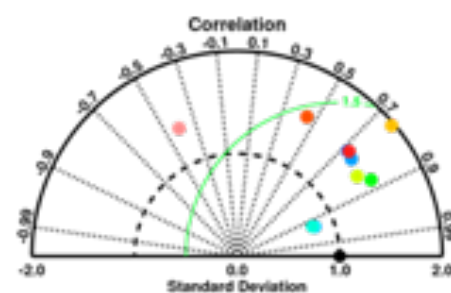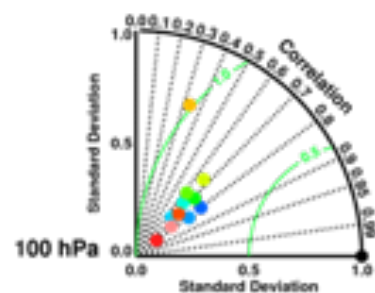
Model performance scores based on spatial mean, variance and correlations

From Jiang et al. (2012)

Scores for Mean, Spatial Standard Deviation and Correlation
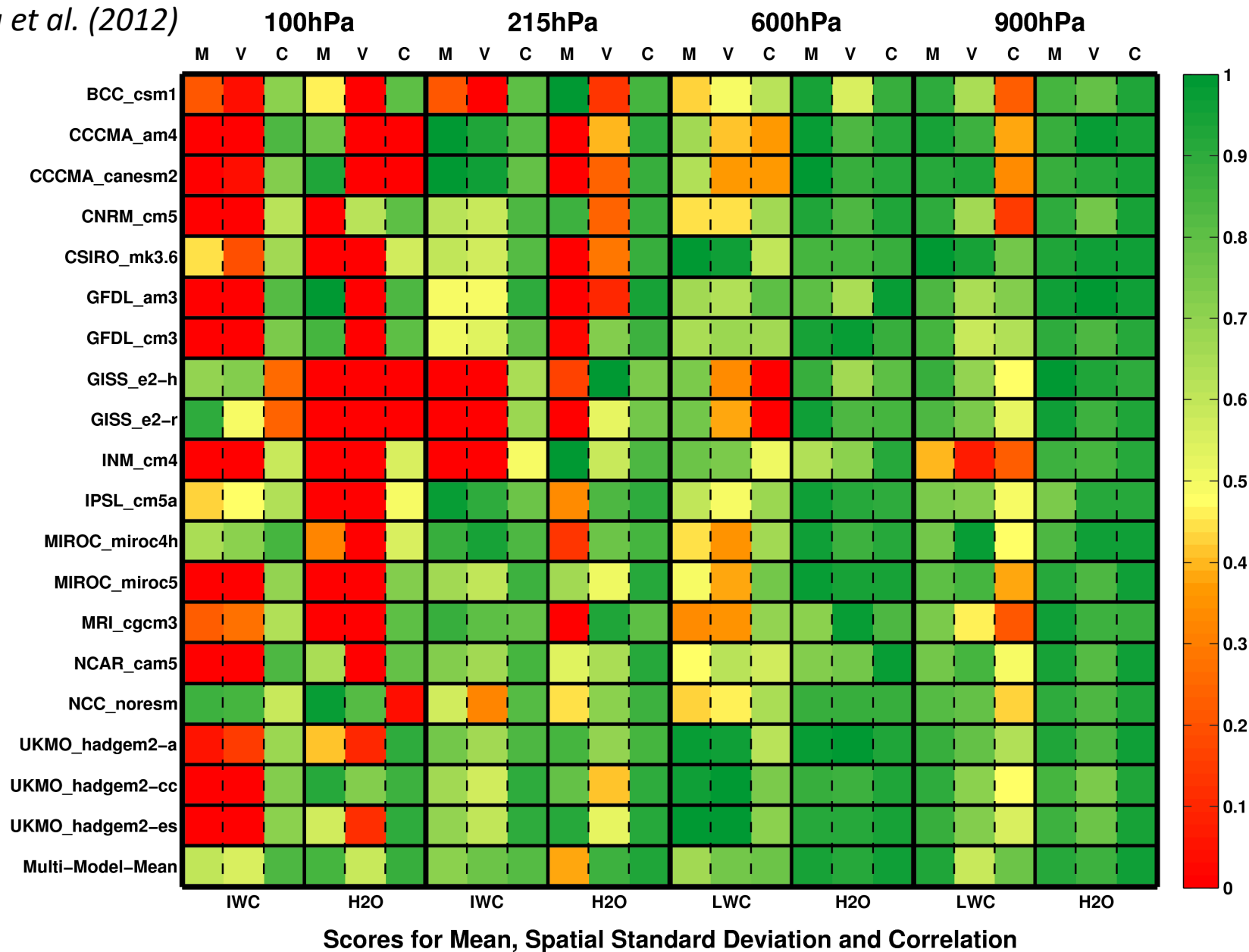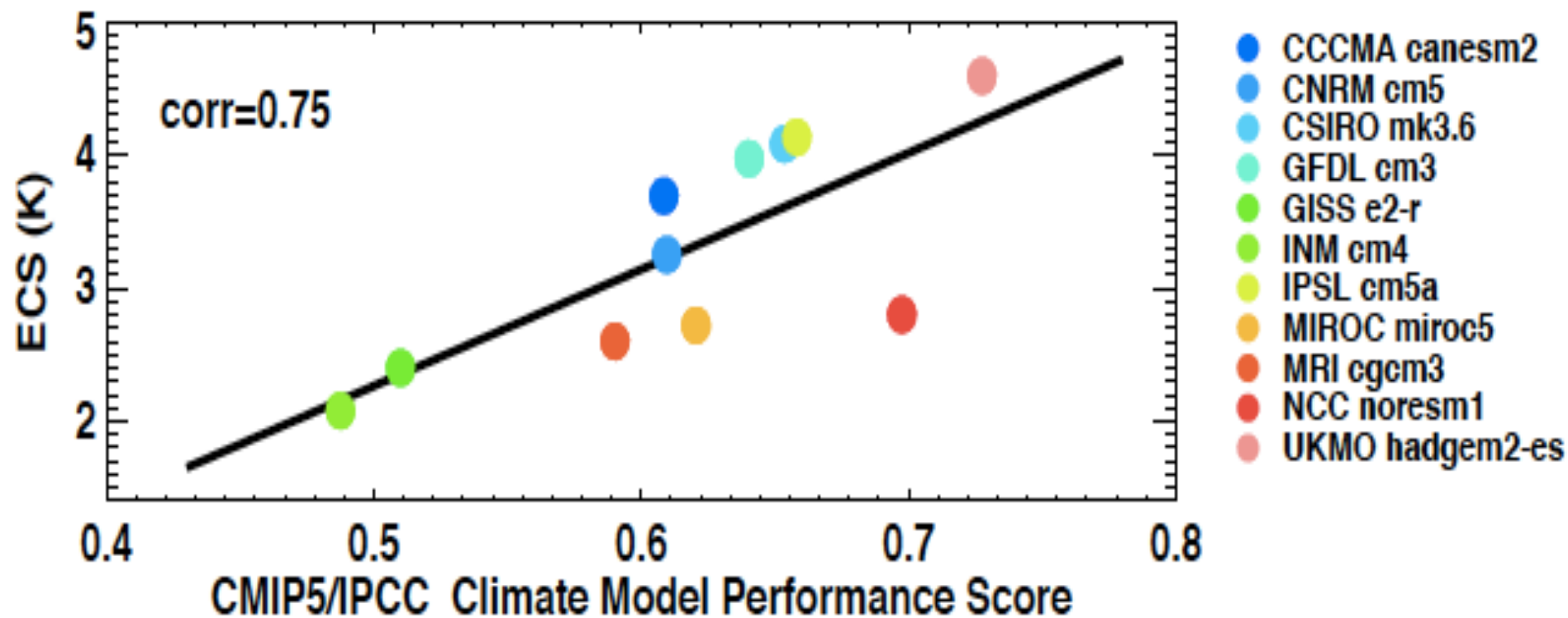
Based on Jiang et al. 2012

Some Preliminary Results for CMIP6

*Jiang et al. (2012)*   *Su et al. (2014)*   *Eyring et al. 2019*

CMIP5 Model	Overall Score	ECS (K)	CMIP6 Model	Overall Score	ECS (K)
BCC csm1	0.56		BCC csm2	0.69	3.1
CCCMA am4	0.62				
CCCMA canesm2	0.61	3.69	CCCMA canesm3	0.73	5.8
CNRM cm5	0.61	3.25	CNRM cm6	0.70	5.0
CSIRO mk3.6	0.65	4.08			
GFDL am3	0.64				
GFDL cm3	0.64	3.97	GFDL cm4	0.72	5.0
GISS e2-h	0.52				
GISS e2-r	0.51	2.11	GISS e3r	0.63	2.8
INM cm4	0.49	2.08			
IPSL cm5a	0.66	4.13	IPSL cm6a-l	0.68	4.6
MIROC miroc4h	0.69				
MIROC miroc5	0.62	2.72	MIROC miroc6	0.60	2.7
MRI cgcm3	0.59	2.60			
MOHC hadgem2-a	0.73				
MOHC hadgem2-cc	0.73		MOHC ukesm	0.75	5.1
MOHC hadgem2-es	0.71	4.59	MOHC hadgem3	0.77	5.8
NCAR cam5	0.65	4.10	NCAR cesm2	0.76	5.1
NCC noresm	0.70	2.80	NCC noresm		5.0

Many improvements have been made to models from CMIP5 to CMIP6, including new physics in the atmosphere, ocean sea-ice and land surface utilizing new observations. Preliminary results show that many CMIP 6 models have a higher ECS than their CMIP5 counterparts.

Some Preliminary Results for CMIP6

High ECS composite   **Low ECS composite**
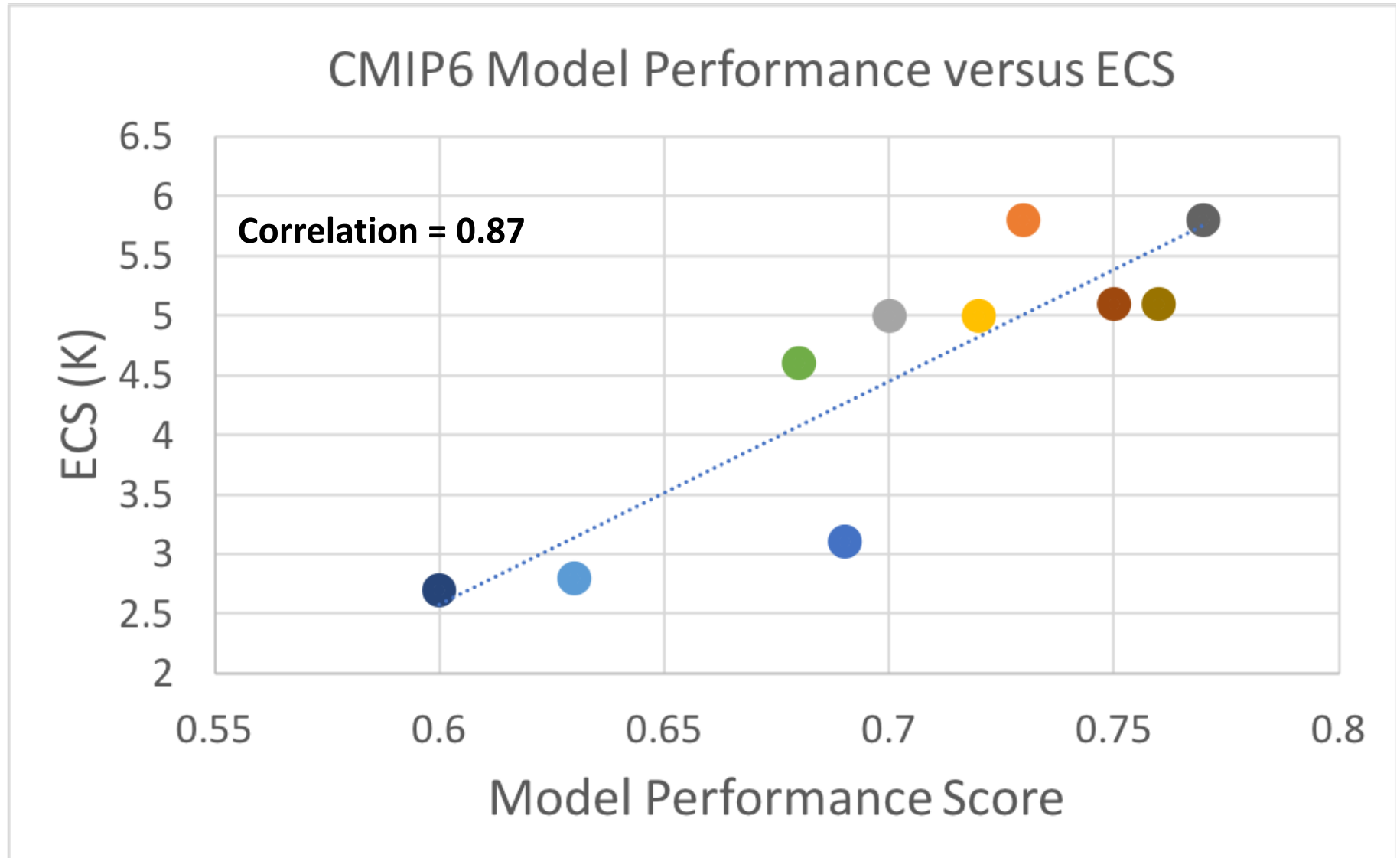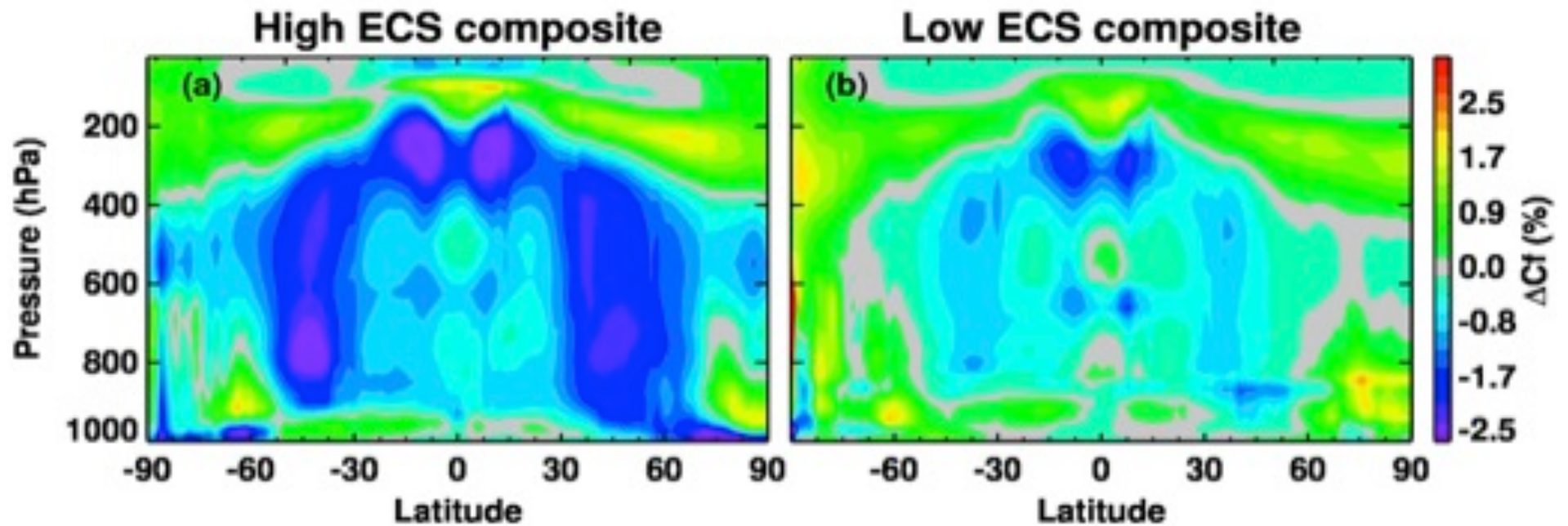
The amplitudes of cloud changes are noticeable larger in the high ECS models

Summary

- We are evaluating CMIP6 clouds and water vapor simulations using observational metrics based on the Aura and A-Train datasets.

- **Preliminary results show:**
  - ✓ **The model errors in the upper troposphere remains the largest, comparing to the errors in mid- and lower troposphere, especially the cloud errors.**
  - ✓ **Model improvements from CMIP5 to CMIP6 are evident in overall model performance scores.**
  - ✓ **Most CMIP6 models in general have a higher ECS than their CMIP5 counterparts, which is correlated with the improvements in model performance.**
    - ➢ Models whose cloud water content and specific humidity deviates more from observations have a lower ECS.
    - ➢ The amplitudes of cloud changes are noticeable larger in the high ECS models

- Our near future plan:
  - To identify key physical mechanisms responsible for inter-model differences in climate-sensitive metrics;
  - To apply a suite of emergent constraints of climate-sensitive metrics onto CMIP6 models to infer the realism of future climate changes in temperature and precipitation.